The global water cycle plays a critical role in the functioning of the Earth system. Through complex interactions, the global water cycle integrates the physical, chemical, and biological processes that sustain ecosystems and influence climate and related global change. Inadequate understanding of the water cycle is one of the key sources of uncertainty in climate change prediction and projections. Clouds, precipitation, and water vapor play important roles in feedbacks that are not well represented in many climate models. Several aspects of atmosphere-land surface interactions, including biological, and terrestrial hydrological processes, are still inadequately understood, leading to deficiencies in their parametric representation in simulation and prediction models which are used for natural hazard forecasting, water resources management, and other decisions of societal relevance. The processes described above alter surface and atmospheric heating and cooling rates, leading to adjustments in atmospheric circulation and precipitation/evaporation patterns. Improved understanding of these processes is essential to developing options for responding to the consequences of water cycle variability and change.

Decision makers, including infrastructure planners, water and other natural resource resources managers, policymakers and other stakeholders, are addressing climate change issues while identifying the mitigation and adaptation measures that can be implemented to cope with long-term changes in the availability, quality, flow, and seasonal timing of surface and subsurface water. State-of-the-art Earth system models used to make projections about future hydrologic conditions often do not provide the adequate type and scale of hydrologic information needed for informed decision making. However, major scientific challenges still lay in advancing from global scenarios to the regional specificity called for by the decision making process, whether at the local, state or federal level.

Priority Science Research Goals

Through improved understanding, observations, monitoring, and modeling, the water cycle program is structured to pursue research on key science issues that provide the basis for a series of applications of significant benefit to a broad range of end communities. Priority science research goals include:

- Develop strategic frameworks to integrate fundamental global water cycle and terrestrial hydrologic research addressing societal needs in a changing climate, including the development and implementation of informed adaptation and mitigation strategies, assessments, and other decision support tools and processes.
- Develop and enhance observing and monitoring networks that provide the necessary data for hydrologic cycle research, end use operations, and provide critical links to other ecosystem services.
- Identify deficiencies in cloud formulations and cloud feedback representations in climate models, and improve cloud processes representations. Quantify the magnitude of aerosol indirect effects on clouds and their effects on precipitation and the broader hydrologic cycle.

- Improve observations and modeling of processes and feedbacks including snow and ice packs freeze/thaw, soil moisture, and groundwater interactions.
- Link global climate models (GCMs) to regional and/or local scale hydrologic models, including the investigation of two way interactions and feedback issues.
- Provide improved simulation and prediction of hydrologic parameters and conditions leading to extreme events, such as floods and prolonged droughts, in the context of changing intensity and frequency of such events.

The federal agencies involved in the Global Water Cycle research element are defining a program of activities that are envisioned to lead to essential, interdisciplinary breakthroughs in water cycle science. Strategies for implementation include assembling long-term data sets of water cycle variables, new tools and techniques, reanalysis of existing records, assimilation of observations and model output, and establishment of a network of observations with new capabilities for collecting and integrating data for interdisciplinary research. Collaboration with

other program elements and end users will be critical in ensuring success. In addition to addressing goals, these ongoing and planned observations and research will contribute to the objectives of a broad array of national and international programs.